Project Title: Developing a Spatial Database of Bat-bushmeat Hunting and Trade to Enhance Conservation Planning and Disease Surveillance in Southern Ghana

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SUMMARY

Bushmeat hunting poses threats to biodiversity and public health. In particular hunting of bats represents a serious threat to bat population and ecosystems. Furthermore, the threat of bat zoonoses is of growing concern as more bat species are identified as vectors of emergent viral diseases. The goal of this Rufford Small Grant (RSG) project was to develop a GIS database to: (1) monitor bat meat hunting and trade; (2) identify locations at risk of potential zoonoses outbreak; and (3) employ a One Health approach to educate local people to protect bats and humans. Our surveys in six communities in southern Ghana revealed that, people are still actively hunting and eating fruit bats despite its being the presumptive reservoir host of Ebola viruses in West Africa. We identified the characteristics of the bat-bushmeat actors, and the scope of their activities in southern Ghana. We estimate that more than 6,000 fruit bats are eaten in a month. In addition to field surveys, we embarked on awareness campaigns in selected communities. Social media platforms were also used to stimulate interest in bat conservation and to educate people on potential risk of zoonotic pathogens from bats. In this report, we provide geographic details about people and places at risk of potential zoonoses outbreak in southern Ghana. Our data is pragmatic and thus can be used to effectively inform disease and conservation management plans.

BACKGROUND

In West Africa, bush meat that includes fruit bats is relied on for animal protein needs and food security. Some communities in southern Ghana eat over 128,000 fruit bats (*Eidolon helvum*) in a year (Kamins et al. 2011), possibly because of its many health benefits (Kamins et al. 2015). However, the local people may be ignorant of the ecological values and health risk associated with eating batmeat (Kamins et al. 2015). *E. helvum* which is widely eaten, host several zoonotic pathogens including deadly Ebola virus (Hayman et al. 2010). Unquestionably, strategies to monitor batmeat exploitation and potential zoonoses occurrence remains a high priority in Ghana. Concurrently, local people should be actively engaged in conservation efforts to motivate them to reduce pressure on bat populations.

This RSG project assessed the scope of the bat meat hunting and trade, and identified areas at risk of zoonoses outbreak in southern Ghana. Specifically, we documented important socio-demographic data on bat-bushmeat actors to determine trends in bat-bushmeat activities and identified people and places that are at risk of zoonotic pathogens from bats.

METHODS

Study site

We surveyed six communities (Asikam, Ntomem, Buoyam, Tanoboase, Tanokrom, Techiman) located within Ghana's High Forest Zone in the south (Figure 1). Our study areas are also home to Ghana's leading bushmeat eating populace. Apart from Techiman, all the study localities are rural towns. Techiman is a semi urban area; has one of the largest bushmeat markets in Ghana which attracts merchants from countries such as Mali, Nigeria, Burkina Faso, Togo and Cote d'lvoire. Asikam and Ntomem are in the Eastern region of Ghana while Buoyem, Tanoboase, Tanokrom and Techiman are in the Brong-East region of Ghana. The communities are characterized by hills, sacred groves, gallery forests and caves, which altogether form a network of important habitats for bats.

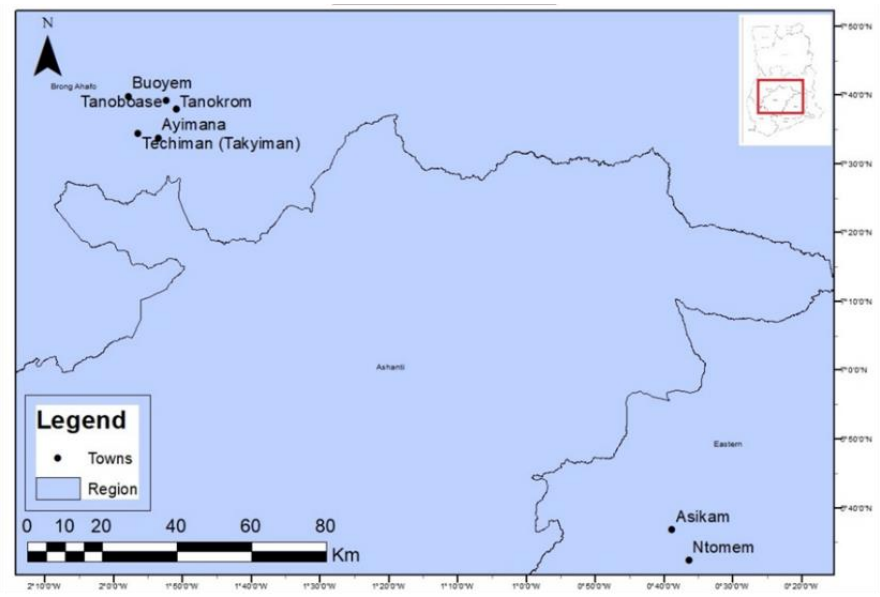

Figure 1: Map showing study localities

Field surveys

Field surveys were carried out over a period of five months, from April to August 2018. We administered the questionnaires to 130 bat-bushmeat actors categorized as Hunters, Vendors and Consumers. In this study, Hunters are defined as individuals who hunt for food or income. Vendors are individuals mostly located in markets and retail bats that someone else has captured. Vendors also included local restaurant operators (Chopbar operators) who sell food prepared from bushmeat. Consumers are those who eat bat meat.

We employed semi-structured questionnaires to collate data. Questionnaires were organized into three main sections. The first section covered socio-demographic information of the respondent; the second section covered information on bat exploitation patterns; the third section looked at behaviours that expose bat-bushmeat actors to bat zoonotic pathogens; and the last section covered the perception of respondents to bat conservation. Hunters and vendors in market squares were identified as described by Swenson (2005). Through these key actors, we were able to identify and conveniently sampled households that are linked to bat meat consumption.

Most questions on hunting were centred on the quantity of bats exploited and the trends of exploitation. For instance, we asked hunters about the quantities of bats they captured in a month and their prices. With a photo guide, we also asked hunters to identify the species they hunted; some vendors and consumers were able to also identify some species of bats exploited within their locality (Figure 2 and 3). We also recorded the geographic locations of all respondents with a Global Positioning System unit (GPS).

To assess the risk or vulnerability to bat zoonotic pathogens, we asked respondents whether they-handle live bats; have had contact with bat blood/bites/scratches; use protective measures such as gloves when handling bats; and eat bat meat.

Since we organized parallel educational campaigns during the data collection, we also assessed the perception of some selected actors about their willingness to protect bats and abandon bat consumption, hunting and selling in the future.

Figure 1: Team member interacting with a bat-bushmeat actor at Ntomem

Figure 3: Some hunters identifying species of bats exploited with the help of a Photo guide at Asikam

Data analysis

We analysed information on socio-demographics, methods used for hunting, species of bats hunted and the times of bat-bushmeat activities by using descriptive analyses in Microsoft Excel 2016. We employed a simple calculation to derive the price of bats sold by averaging the unit prices of bats sold by hunters and vendors, and also bought by consumers. We calculated the actual number of bats harvested in a month using the answers provided by the hunters. We assumed that the number of bats consumed and sold originated from hunters from the same area. We only included

numbers quoted by vendors and consumers who purchased their bat meat from areas outside our study localities. This procedure was adopted to avoid duplicating counts.

We evaluated the vulnerability of each respondent to bat zoonotic pathogens based on their responses to questionnaires. Thus, if a respondent does any of these activities; eat bat meat, handle live bats and do not use protective measures when handling bats, they were automatically categorized as Vulnerable/At risk of bat zoonotic pathogens. If a respondent prepared/butchered bats or have had contact with bat blood/bites/scratches, we categorized them as High risk/ High susceptibility to bat zoonotic pathogens. With the risk information and GPS coordinates of all respondents, we developed maps to show places that are at risk of bat zoonoses using ArcGIS version 10.3.

RESULTS & DISCUSSION

Characteristics of Bat-bushmeat Actors

We interviewed a total of 130 bat-bushmeat actors in six localities (Table 1). During the entire survey, we encountered more Hunters (N=68) compared to Consumers (N=56) and Vendors (N=6).

In the proceeding sections, we looked more closely at some important characteristics of the bat-bushmeat actors who participated in our interviews.

Table 1. Distribution of respondents in survey

Community	Respondent category			Total interviews
	Hunters	Vendors	Consumers	
Asikam	11	1	15	27
Buoyem	2	0	0	2
Ntomem	19	0	14	33
Tanoboase	26	2	22	50
Tanokrom	7	0	3	10
Techiman	3	3	2	8
Total	68	6	56	130

Age

Participants were distributed over a wide range of age groups. Majority of them (N=66;50.8%) were within the age class 30-59 years compared to 18-29 years (N=41;31.5%), below 18 years (N=12;9.2%) and 60 years and above (N=11;8.5%). The total number of participants varied for the various bat-bushmeat actors interviewed. Results revealed that most people who were engaged in either hunting, selling or eating bat meat were 18 years and above (Table 1; Figure 4).

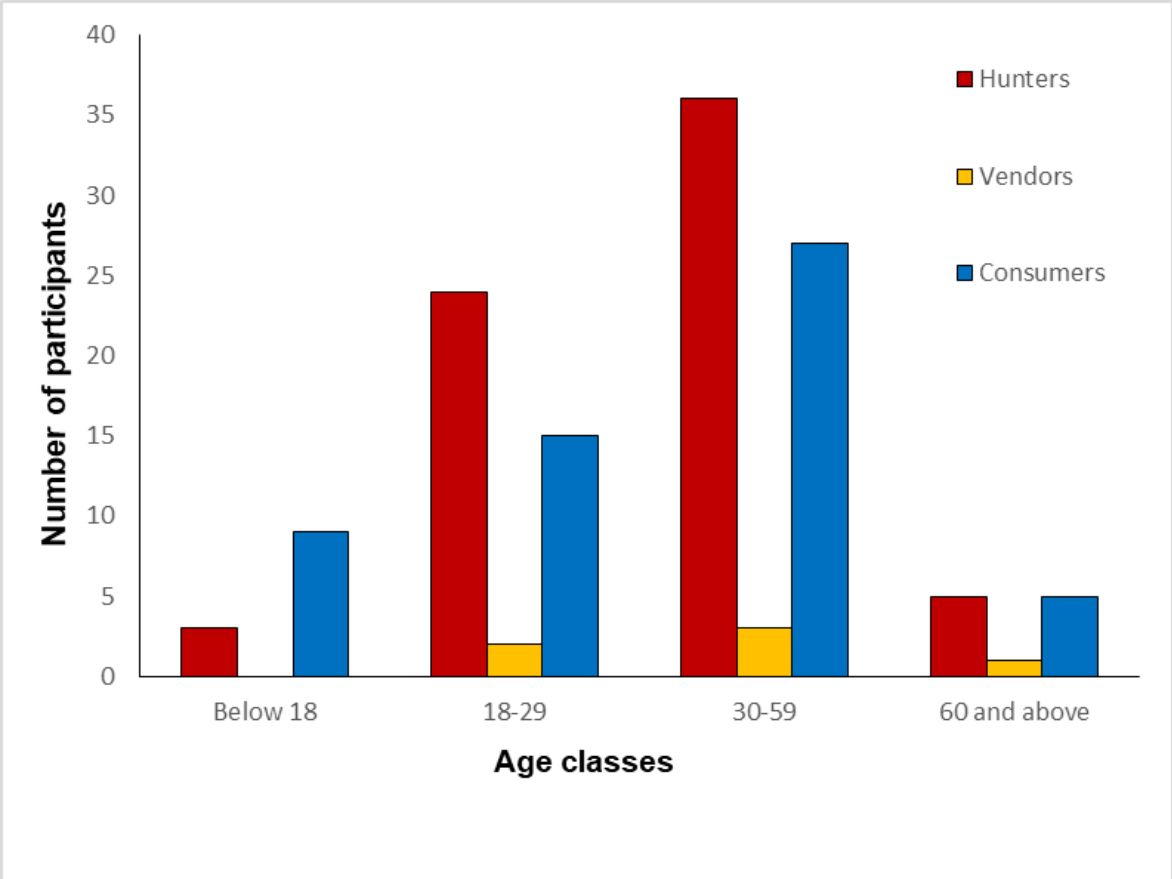

Figure 4. Age classes of bat-bushmeat actors (Hunters, Vendors, Consumers).

Gender

Majority (N=92;70.8%) of bat-bushmeat actors were males compared to females (N=38;29.2%). All the hunters interviewed were males except six (6). Three (3) out of the six (6) vendors who sell in the market were females; one of them from Dwomo in Techiman operated as a food vendor (local eatery joint popularly referred as Chopbar). We recorded more female (N=29) consumers compared to males (N=27) (Figure 5).

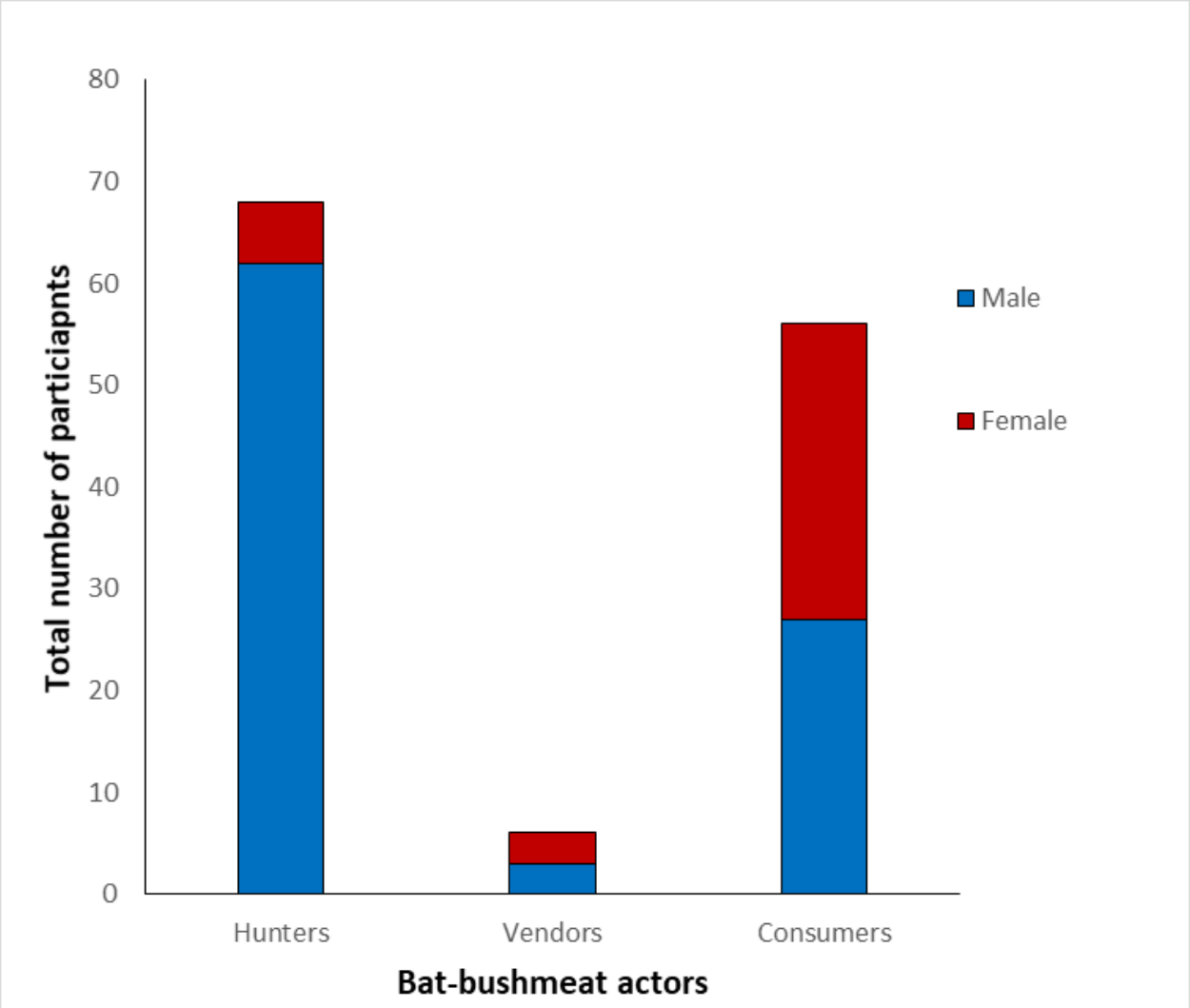

Figure 5. Gender distribution of bat bushmeat actors.

Education

Most of the participants (N=102: 78.5%) had some form of formal education, compared to only 21.5% (N=28) with no formal education. The highest educational level for hunters was the Tertiary level (Higher Education equivalence in the UK); this group comprised four (4) male hunters living in villages (Ntomem, Tanokrom and Tanoboase). One of them reported that he worked in the banking sector and at the same time as a farmer. The remaining tertiary level hunters were unemployed. The highest educational level for the vendors was Secondary level (Secondary

education equivalence in the UK) (Figure 6). Three (3) consumers had attained Tertiary education; they all lived in villages (Tanoboase and Asikam) and worked in teaching and faming.

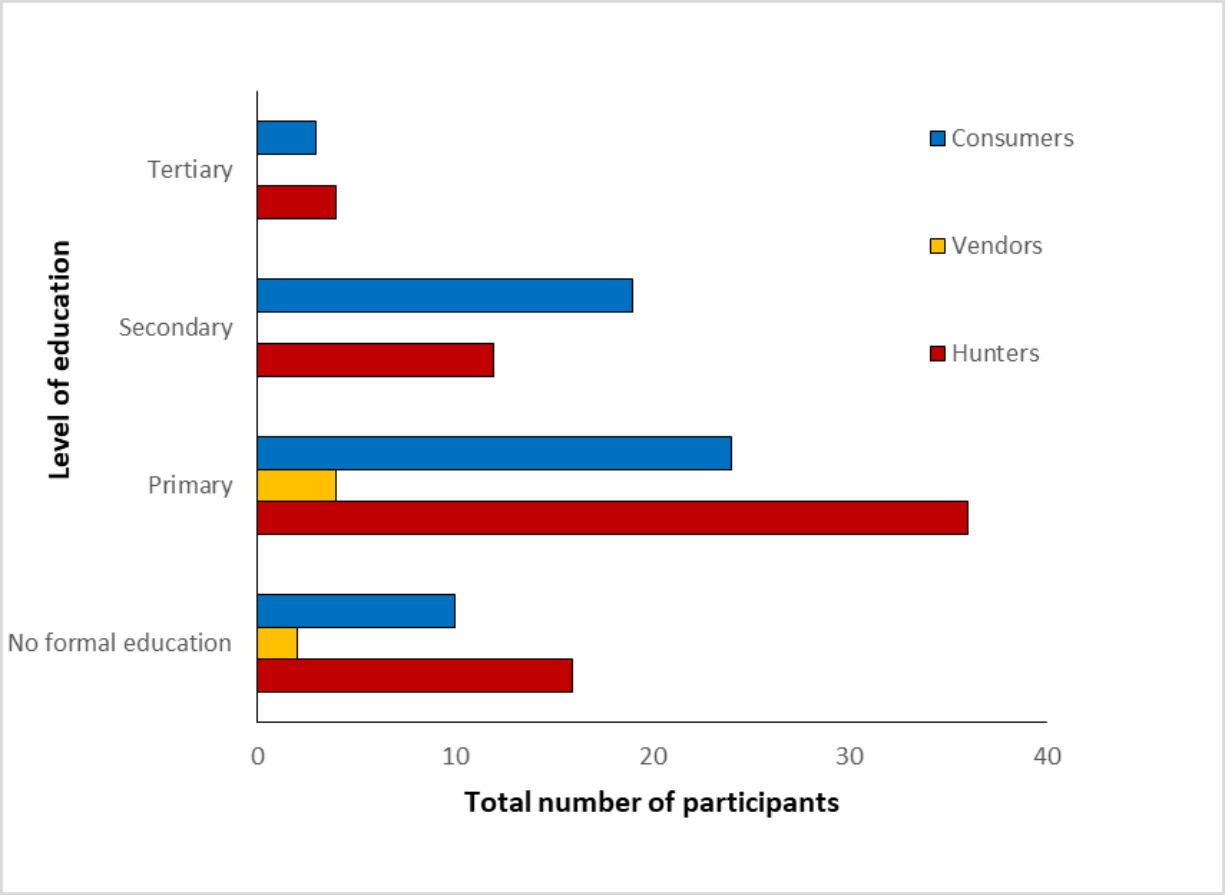

Figure 6. Education level of the various bat-bushmeat actors (hunters, vendors, consumers).

Bat meat Exploitation Patterns

Timing of bat meat exploitation

Only 6.2% (N=8) of the total participants could not tell when in the year they carried out their activities. Hunting and eating of bats were reported all year round, with highest records from July to September in this survey. In contrast, trading of bat meat by vendors in the market was reported to occur only at certain times of the year, with peak activities from April to June (Figure 7). We attribute the different exploitation patterns especially in the peak of activities between hunting and trading in our study to two major factors: (1) most hunters sold or gave out their catch directly to consumers in almost all study sites; (2) bats rarely occur in bushmeat markets in Ghana (Kamins et al. 2011); this may as well account for the small number of vendors we encountered during market surveys.

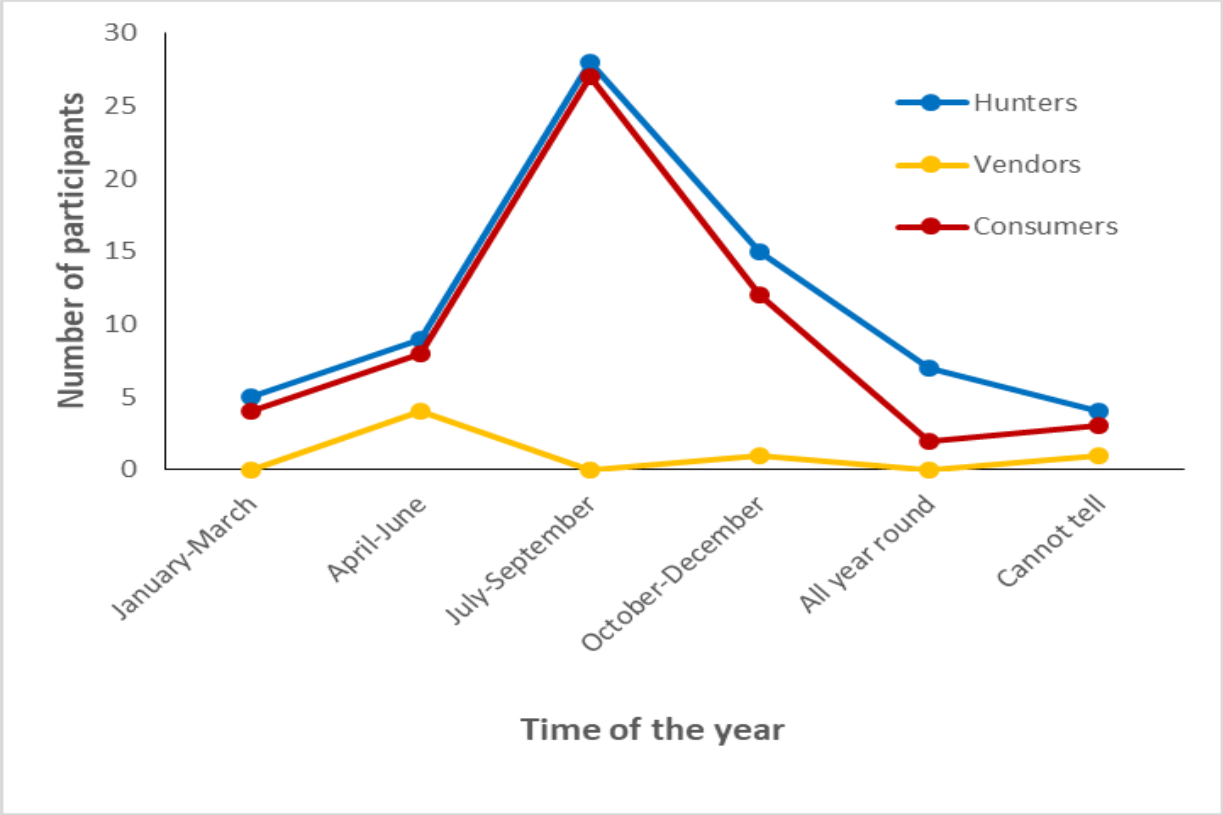

Figure 7. Timing of bat-bushmeat activities (Hunting, selling and trading) reported by interview participants (Hunters, Vendors, Consumers).

Species of bats exploited

The straw coloured fruit bat *Eidolon helvum* was exploited widely (Table 3) across all the study sites. All vendors interviewed sold only *Eidolon helvum* in the market. Other species reported to be exploited and sold included: Egyptian fruit bat *Rousettus aegyptiacus* (reported in Buoyam, Tanoboase and Tanokrom); Gambian epauletted fruit bat *Epomophorus gambianus* (reported in Techiman, Tanoboase); and Egyptian slit-faced bat *Nycteris thebaica* (Tanokrom). Bats hunted were sold as fresh or roasted/smoked carcass. Vendors roasted/smoked and/or cooked bats before they were sold or consumed (Figure 8).

Table 3: Species of bats exploited in study sites by batmeat actors

Species	How many times the species was mentioned	Percentage based on responses
Eidolon helvum	125	86.2
Rousettus aegyptiacus	10	6.9
Nycteris thebaica	1	0.7
Epomophorus gambianus	9	6.2
Total	145	100

Note: Some respondents reported to exploit more than one species therefore the total responses exceeded the total number of participants (130) we interviewed for our study.


Figure 8: Smoked bat meat displayed on a table in Techiman Market

Methods and reasons for hunting

Hunters used shooting, catapulting and netting (they reported to use large nets which more than three people hold under bat roosting trees. The hunters either shake trees for bats to fall in the net or shoot bats and capture them with net) as methods of hunting bats across the study sites. The most frequently used method is catapulting (Figure 9). Two participants (consumers) reported to occasionally scavenge from leftovers of hunters although this was not considered among methods used by hunters. No hunter reported having a legal permit from the Ghana Wildlife Division (Ghana's authority for protecting wildlife resources including bats) to hunt bats. Some hunters claimed they had permission from their community elders (mostly the Chief) to hunt. Bats were hunted from various locations in and around our study sites. In Asikam and Tanokrom, bats were hunted from the forest and bushes in the locality. In Buoyem and Ntomem, bats were hunted in caves. In Tanoboase, bats were hunted in surrounding forests and in caves in the Tano Sacred

Grove. Hunters in the urban Techiman city, hunted bats from neighbouring villages such as Tanoboase and Akisimasu. Apart from our study localities, two vendors reported they also go as far north of Ghana to purchase bat meat. This can either be a sign of increased demand for bat meat, or declining bat populations in southern Ghana.

Majority of hunters (N=47; 69.1%) hunted for food compared to only a few (N=15; 22.1%) who hunted for both food and income, and only income (N=1; 1.5%). Five (7.4%) hunters did answer this question; See Table 2 below. Hunters mainly hunted for extra income and to feed their families, with some attributing chronic poverty as a reason for hunting bats (e.g. see Appendix 5 for some narrations by hunters). In fact, some hunters reported that bats are easy and fun to hunt, and so fetch quick money. Others hunted because people like bat meat and requested for them. Likewise, the few vendors we interviewed also sold for money to support their families and also based on people's request. Apart from food, we did not document any other uses of bats harvested from the wild.

The average unit price of bat meat reported in all the study sites was GH¢3.2 (£0.47). Thus, the price of a whole bat meat ranged from GH¢0.6 (£0.09) to GH¢15 (£2.20). Prices were calculated

from reports of all the participants we interviewed. This price range shows that, trading in bat meat is not very profitable especially when compared to selling other common meat such as grasscutter which has a price range from GH¢ 80 (£11.74) to GH¢ 200 (£29.35).

In total, hunters harvested 5,026 bats in a month across all the study sites. Thus in Tanoboase, 2,855 bats were hunted in a month compared to Ntomem (1,083 bats), Asikam (745 bats), Tanokrom (178 bats), Techiman (135 bats) and Bouyem (30 bats). We documented additional 1,442 records from consumers who purchased their bat meat from vendors that we missed during our surveys. Therefore, we assume these vendors may have purchased their bat meat from hunters that we also missed in our surveys. We estimate that a minimum of 6,468 bats are harvested in a month. This figure may even be an underestimation since some respondents declined to provide the quantities of bats they used.

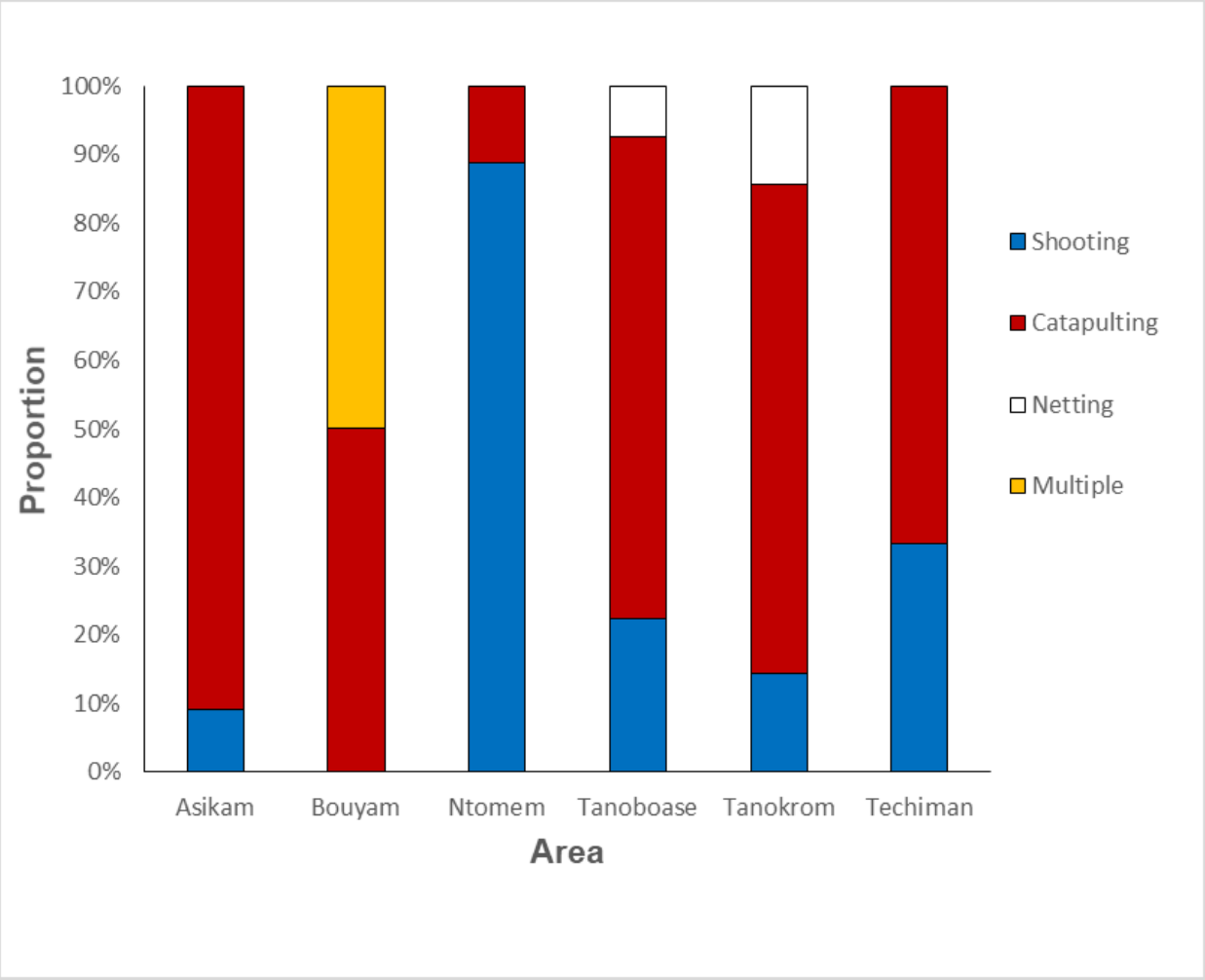

Figure 9. Different hunting methods across the interview sites. All the sites are rural areas except Techiman which is a semi-urban area.

Table 4: Reasons for hunting bats. Five hunters did not answer this question.

Reason	Number of respondents (hunters)
Sell	1
Personal/family consumption	47
Both (selling & personal use)	15

Years Actors have engaged in bat-bushmeat activities

Overall, 12.3% (N=16) of respondents could not tell the number of years they have been engaging in bat-bushmeat activities. In total, majority of the actors (N=44; 33.8%) had been conducting their activities from 1- 5 years since 2018 (survey period). This year range (1-5 years) also dominated for all the individual actors when compared to the other reported age classes. Only few actors (N=7; 5.4%) have been conducting their activities within less than a year (2 weeks - 3 months) before our survey in 2018. The rest of the actors have been engaging their activities from 6-10years (N=25;19.2%), 11-20 years (N=23;17.7%) and above 20 years (N=15;11.5%) (Figure 10).

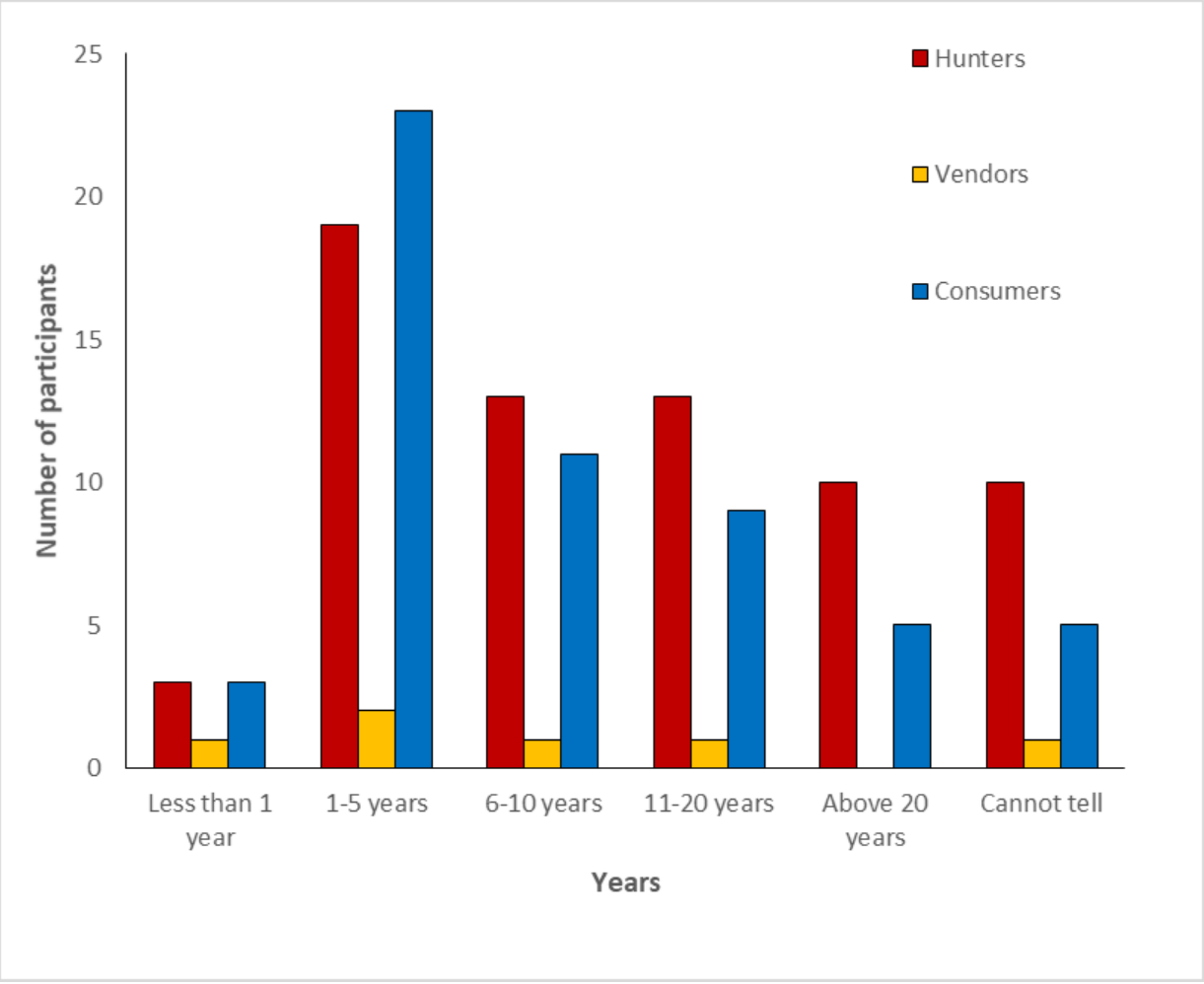

Figure 10. The various actors (hunters, vendors, consumers) and the years they have been engaging in bat-bushmeat activities since our surveys in 2018.

People and places at risk of Bat Zoonoses

All hunters reported they eat batmeat. Also, all hunters but sixteen (23.5%), reported handling live bats. Majority (N= 64; 94.1%) of the hunters reported that they prepare/butcher bats. They gutted the bats, smoked and sometimes chop them up. The majority (N= 46; 67.6%) of the hunters also reported they have come into contact with bat blood (18 hunters further reported getting scratched and 10 hunters mentioned being bitten). Only two (2.9%) hunters reported using protective clothing such as gloves when handling bats. Based on the above mentioned behaviours, we consider 92.6% (N=63) of the hunters we interviewed to be at a "High risk", and thus, they have a high exposure to bat zoonotic pathogens. We also classified the remaining 7.4% (N=3) to be "At risk''/vulnerable to bat pathogens. In fact, all the hunters we interviewed are vulnerable to bat zoonoses.

All the vendors apart from one reported to also eat batmeat. Only one vendor reported that she occasionally prepared/butchered bats; the rest always prepared/butchered bats. Also, only one vendor reported using gloves when handling bats. Therefore, out of the six vendors interviewed, five (83.3%) of them were classified to be at a ''High risk'' of contracting bat pathogens.

Majority (N=33; 58.9%) of local people who identified themselves as consumers during surveys, reported they butchered/prepared bats. They prepared bats by removing the gut, chopping bats into pieces and roasting/smoking bats. No consumer reported using protective measures such as gloves when handling bats. Like the hunters and vendors, we also consider all the actors who identified as consumers to be vulnerable to bat pathogens. In fact, we classified 62.5% (N=35) of consumers to be highly susceptible (High risk) to bat pathogens.

We also rate all the surveyed localities as vulnerable to bat zoonoses outbreak (see Figure.10, 11 & Appendix 3). Based on the number of respondents classified as High risk to bat pathogens, we have identified Tanoboase to be particularly at a high risk followed by Ntomem, Asikam, Tanokrom, Techiman and Bouyem. The differences in the risk levels of these communities can be attributed to the differences in the number of participants interviewed in these respective communities. As the total number of harvested bats estimated for the respective localities also follows the same trend as the risk levels. Thus, the fact that high number of participants equalled high records of bat captures/harvest and high risk. More so, in the Brong-East region, we started our surveys and spent more days at Tanoboase and went to the other localities (Tanokrom, Bouyem and Techiman) based on information we gathered. The same can be said for the Eastern region where we began in Ntomem then followed to Asikam. Therefore, we believe that the differences in survey efforts may have also resulted in the above patterns. Nevertheless, a closer look at Tanokrom shows that all the participants we encountered except one were classified as High risk. We believe further surveys to interview more people may have increased the number of participants classified as High risk. Thus, we consider Tanokrom among the top localities (Tanoboase, Ntomem and Asikam) at a high risk of zoonoses outbreak. Participants at risk of bat pathogens in Tanoboase were clustered within 0.8Km^2 compared to Tanokrom (1.46Km^2), Ntomem (1.34Km^2) and Asikam (0.44Km^2). See Figure 11 below for more details. It should be noted that, the locations on the map (shown as points in Figure 11) may or may not be the permanent residents of the actors; however, these are places/locations they frequent within their vicinity.

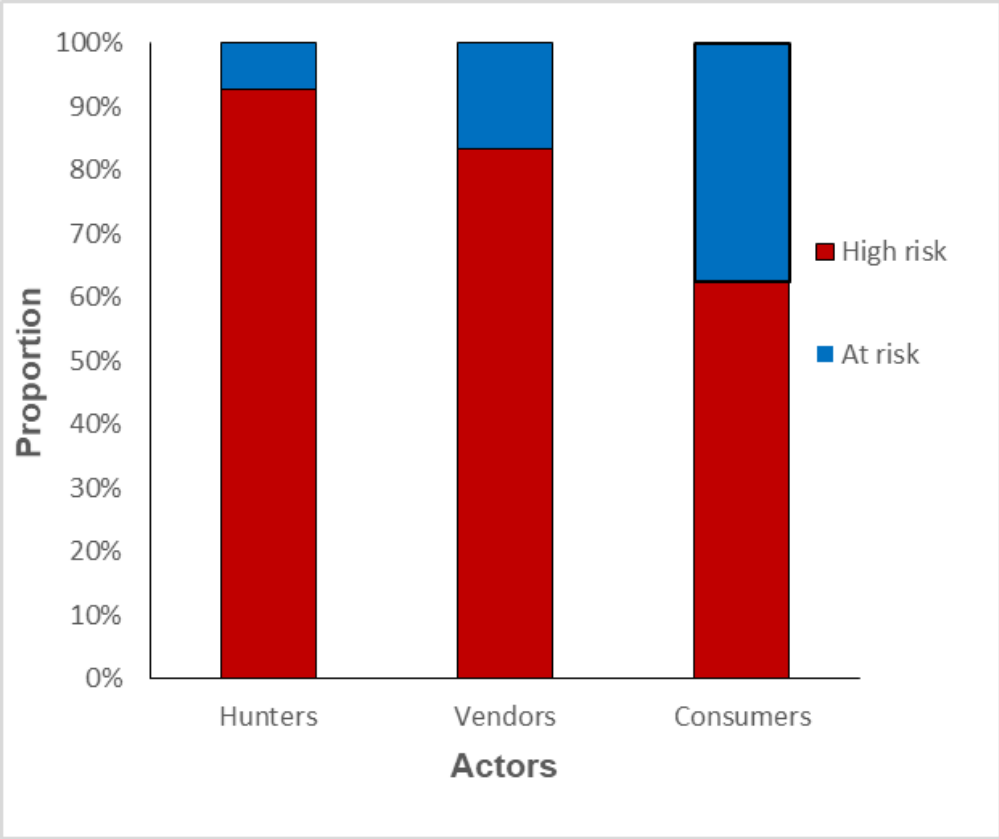

Figure 11. Risk categorization of bat-bushmeat actors. Risk categorizations represents the level of susceptibility to bat zoonoses; as susceptible and very susceptible.

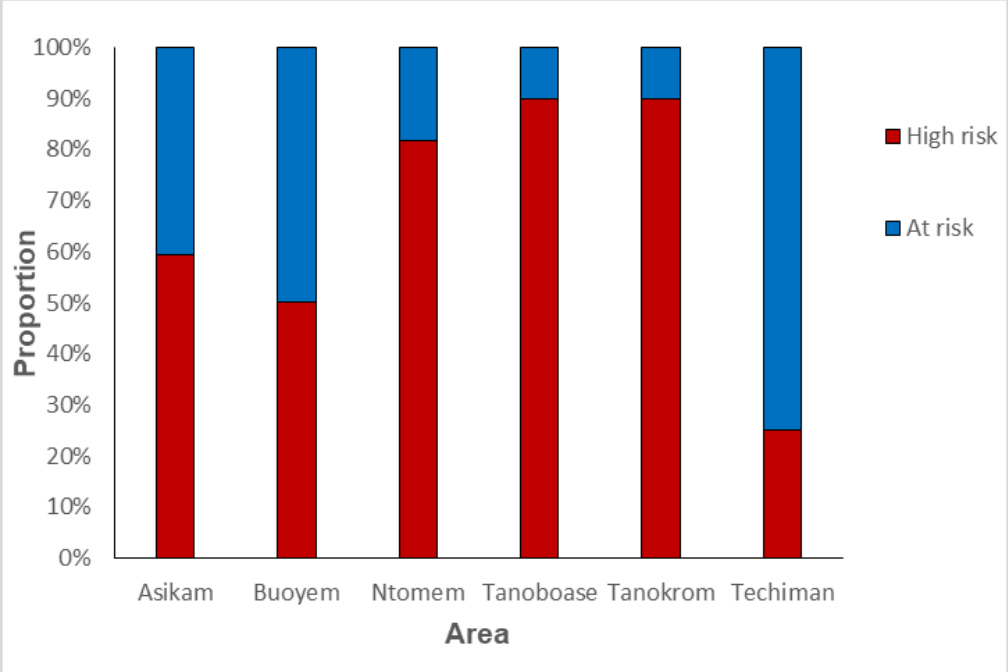

Figure 12. Risk categorization of bat-bushmeat eating communities. Tanoboase, Ntomem, Asikam and Tanoboase are at a High risk to bat zoonoses outbreak.

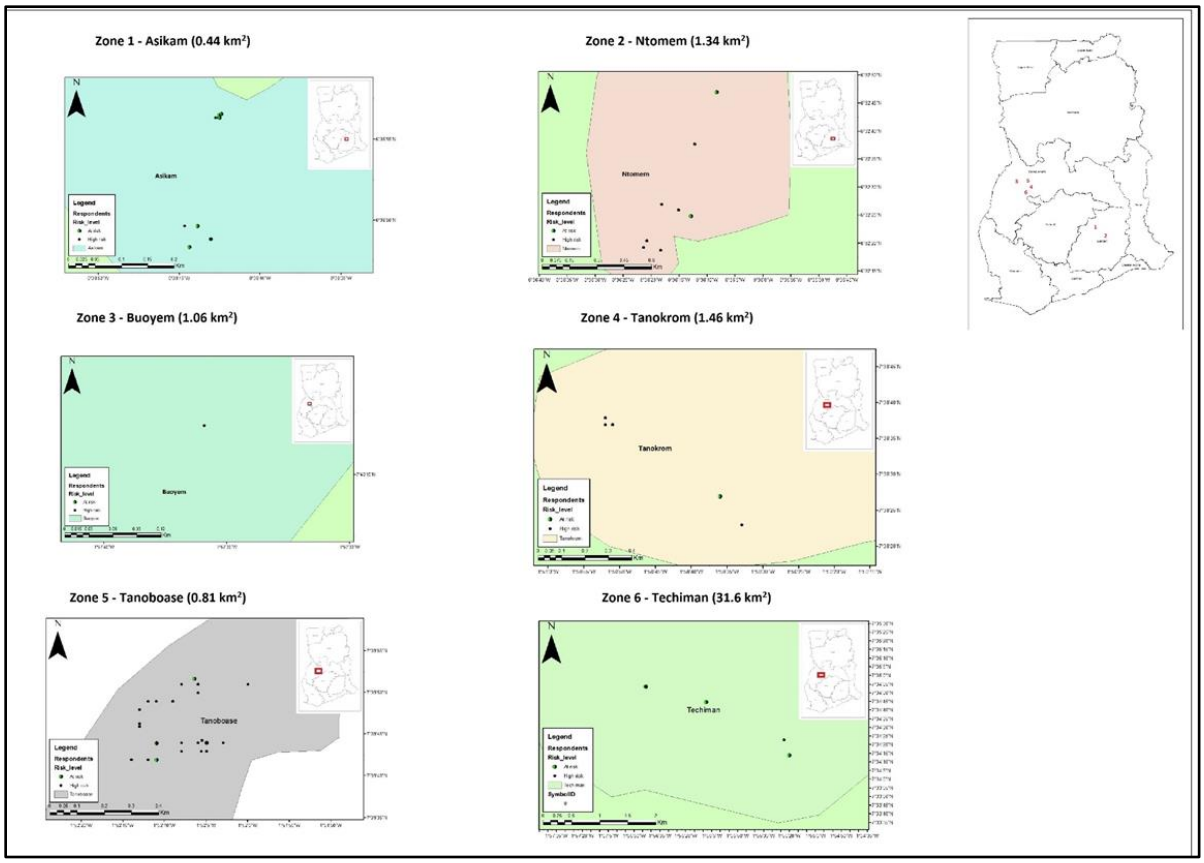

Figure 13. Map showing bat zoonotic outbreak hotspots in all the study localities. Appendix 3 further visualises the individual maps shown here.

Perception/attitudes towards bats

When bat consumers were asked the open question of why they eat bat meat, the major responses were that: it tasted good (N=22;38.8%); it served as meat (N=11;20.4%) and because bat meat was affordable and easy to get (N=7;12.2%). The remaining respondents (N=16;28.6%) shared various reasons that included: because bats are their traditional meat and they also took over; curiosity (e.g. they saw their parents eating bats and they decided to try); because bats are used in preparing soup a lot by their parents so they have no choice than to eat. No actor reported to know anyone who has gotten ill from eating bat meat and butchering/preparing bats.

After our educational campaigns in bat eating communities, we asked some selected actors whether they will protect bats in the future now that they are aware of the positive ways bats help our environment and that eating them is harmful even fatal to humans. All hunters were willing to stop hunting if they have alternatives except two hunters who said they are not sure about quitting hunting. Likewise, all consumers we encountered again said they will consider stopping eating bat meat when provided with alternatives, except nine (9) who said they will continue to eat and another seven (7) who were not sure if they will continue eating batmeat when provided with an alternative. Three (3) vendors said they will quit selling when provided with alternatives, two (2) said they will continue to sell even with alternatives.

Awareness Creation and Community Engagement

We launched educational campaigns in schools and community centres in all the six localities we surveyed. We organized video shows and talks in community centres. We used power point presentations in schools and distributed educational materials including project branded T-shirts, fact-sheets and flyers to schoolchildren and their teachers. Throughout these campaigns we adopted a "risk-benefit" communication approach to educate local people. As the One Health simultaneous communication approach of both risk and benefits (e.g. see Lu et al. 2016) has proven experimentally effective worldwide, we believed it will be promising to effect change in our study. Therefore, we outlined the importance of bats such as ecological indicators, enhancers of vegetation growth and pollination, control of agricultural pest and mosquitoes that causes malaria. At the same time, we educated local people about the dangers of engaging in bat-bushmeat activities, explaining the common bat zoonoses especially Ebola and ways of preventing them. Local people attended in their numbers and fully participated in all our activities. In addition to community campaigns, we launched an online educational program (on Facebook, LinkedIn and What's App) dubbed Bat Lives Matter in Ghana; where we promoted knowledge of bats and their zoonoses, and inspired interest in bat conservation.

Figure 14. Education outreach at a community school in Asikam


Figure 15. Community meeting at Ntomem

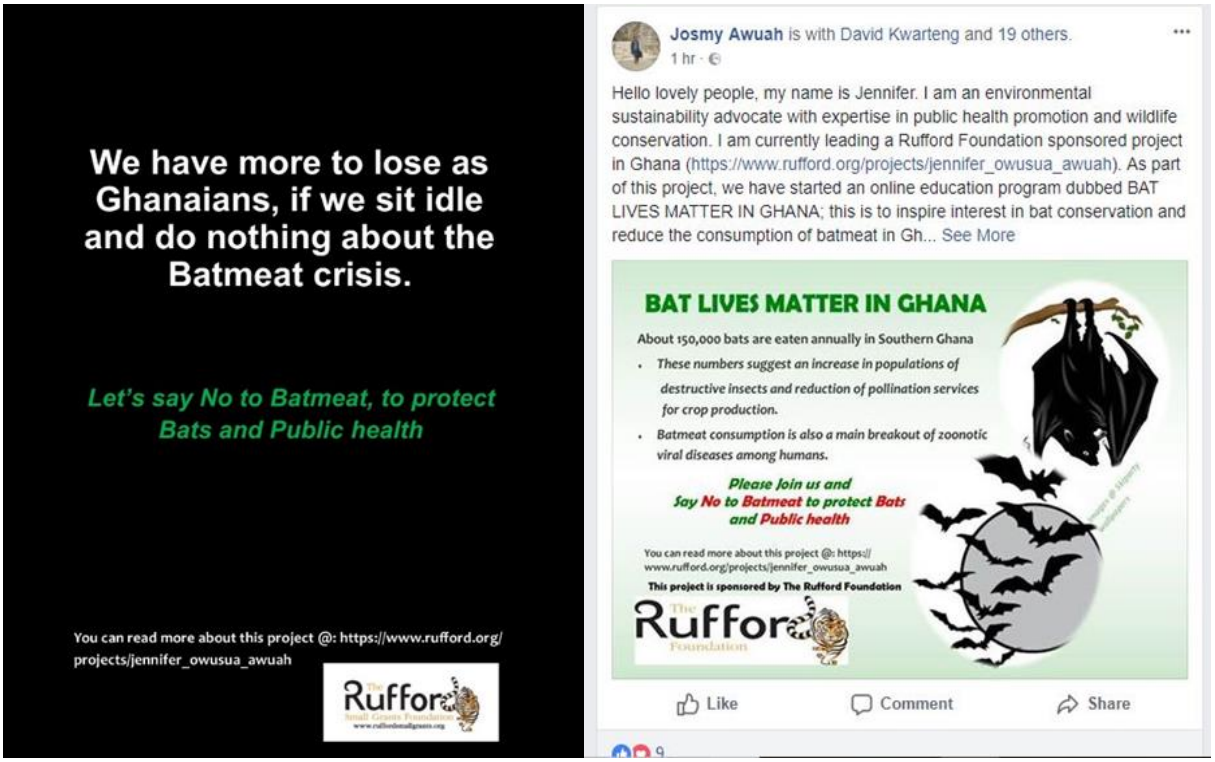

Figure16. Blog posted on Facebook and other social media platforms

CONCLUSION

It is evident from this survey that people are still actively hunting and eating fruit bats in southern Ghana despite the Ebola crisis, which was partly associated with fruit bats in West Africa. Perhaps this is due to the fact that no incidence of Ebola has been reported in Ghana. In fact, none of the participants had seen or known anyone who have gotten a disease from eating bats. It is also clear that trading in bat meat is not a very lucrative business, and that delicacy for bat meat and the need for a source of protein/food were the main reasons people crave for bat meat. The former is in part due to chronic poverty, which forced people who cannot afford other sources of protein to depend

on bat. As some participants also reported that bats are easy to hunt. In fact, participants who harvested more bats were those who used shooting as a method of hunting. There was no restriction or regulation on hunting bats in our study sites. Even some participants asserted that their community leaders have given them permission to hunt bats. Currently there are no specified protocols on hunting and use of bats in the Ghana Wildlife Conservation Regulation L.I.685; This legal document lay down restrictions on hunting, use and exporting of different species of animals. We recommend synergistic approaches to tackle this bat meat crisis in southern Ghana. We need to step up awareness creation in bat eating communities. This should be done by working closely with bat-bushmeat actors to design robust and long term educational programs to suit their specific needs, such as risk level and educational backgrounds. We also recommend the implementation of alternative livelihood options that will help actors to generate some income and access other protein sources. We believe the problem with bat delicacy can be effectively tackled by enacting and implementing laws and regulations concerning bat-bushmeat activities. This can be achieved at the community and national levels, thus working with traditional/opinion leaders and the Ghana Wildlife Division to implement restrictions.

Another potential threat to bats we uncovered is their alleged destruction of cashew farms. Cashew nut is an important cash crop in Ghana. Some colonies of fruit bats use cashew farms as feeding fields in Ghana. The widely held belief that bats destroy this crop can lead to the massive persecution of bat populations by local farmers in the future. We suggest investigations to shed more light on this subject.

ACKNOWLEDGEMENTS

This project was made possible with funding support from the Rufford Small Grants. We are therefore indebted to the Rufford Foundation for all the accomplishments this project has made. We are also very thankful to Dr. Bright Obeng Kankam, Dr. Sam Davis and Dr. Ruth Cross for their advice and endorsements of this project. Finally, we thank all the local communities we surveyed and the host families and assistants for their support to our project.

APPENDICES

Appendix 1: Sample Questionnaire (for hunters); the same questions applies to all the other actors (Vendors and Consumers)

Questionnaire to gather Data towards developing a Spatial Database to Enhance Conservation of Bats and Surveillance of their Zoonoses in Southern Ghana

Target actor: Hunter **Interview Location (Name/GPS reading):**

A	Please complete the following questions about yourself:				
1	Age:	below 18 years	18-29	30-59	60 and above
2	Sex:		Male		Female
3	Education:	No formal education	Primary	Secondary	Tertiary
4	Main/additional occupation:				
5	Religion:	Christian	Muslim	Traditional	Other
6	Residential information:	Name of suburb		Street name	
		House number		GPS coordinates	
7	What is the total number of members of your household?				
B	Please answer the following questions about your bat hunting activities				
8	What species of bat do you hunt?	Eidolon helvum		Other species	
	Please can you describe the species				
9	When in the year do you hunt bats?				
	January – March	April – June	July – September	October – December	
10	Where do you hunt bats?				
11	Do you know when all wildlife hunting except grasscutter is banned in Ghana?				Yes/No
	January 1-April 1	May 1-July 1		August 1- December 1	
12	How do you hunt bats?				
	Catapulting	Live catching	Netting	Shooting	
	Other (please explain)				
13	How often do you hunt bats?				
	Daily	Once a week	Several times a week	Monthly	Several times a month
14	How many bats do you catch per hunt?				
15	How long have you engaged in bat hunting?				
16	Where did you get your permits to hunt bats?				
	Please describe the permit (s)				
17	Do you sell your bats?				Yes/No
	If yes, answer these questions:				
	Who do you sell your catch to?	Consumer	Chopbars	Vendor in market	
	Where (location) do you sell your catch?				
	How much (Ghana cedi), do you sell your catch for?				
	Which form do you sell your bats?				

	Carcass	Fried	Live	Roasted/smoked	Other
	If you do not sell your bat(s), what do you use your catch for?				
C					
18	Do you eat batmeat?				Yes/ No
19	Do you handle live bats?				Yes /No
20	Do you prepare/butcher bats?				Yes/No
	How often do you prepare bats yourself (butcher or smoke them)?				
	Rarely	Sometimes	Often	Always	
	What do you do?				
	Remove guts	Skin	Chop up	Smoke	
21	Do you have contact with bat blood/bites/scratches?				
	Yes/Specify			No	
22	Do you wear protective clothing (including gloves) when handling bats?				
	Yes/Specify			No	
D					
23	Why do you hunt bats?				
24	Why do you eat batmeat				
25	Do you think you can get a disease by hunting bats?				Yes/No
26	Now that you are aware of the positive ways bats help our environment and that eating them is harmful even fatal humans, would you consider:				
	Protecting bats in the future				Yes/No/Not sure
	Stopping hunting				Yes/No/Not sure
	Limiting hunting				Yes/No/Not sure
	Stop hunting if I have alternative				Yes/No/Not sure

Appendix 2: Maps showing the distribution of places at risk of bat zoonoses outbreak

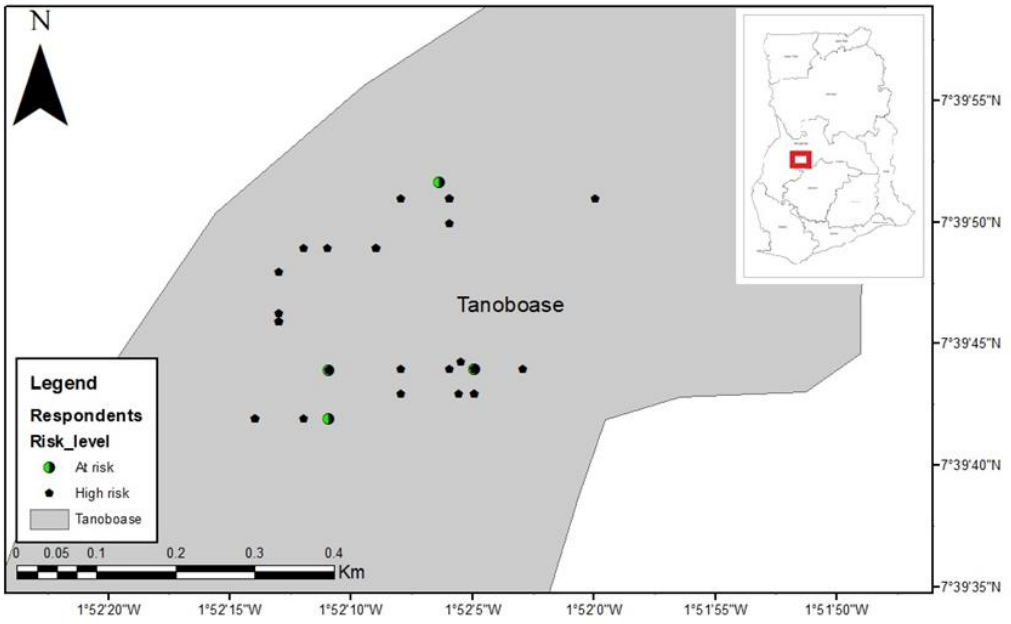

Figure: 15. Map of Tanoboase showing bat zoonotic outbreak locations. Tanoboase was ranked as the most vulnerable locality to bat zoonoses outbreak.

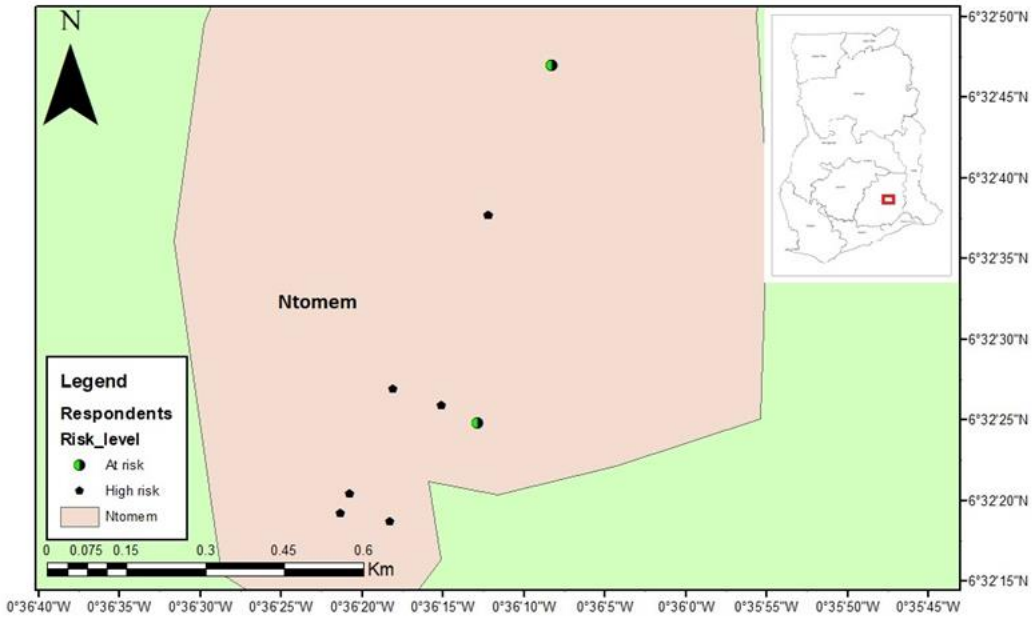

Figure: 16. Map of Ntomem showing bat zoonotic outbreak locations. Ntomem was ranked the second most vulnerable locality to bat zoonoses outbreak.

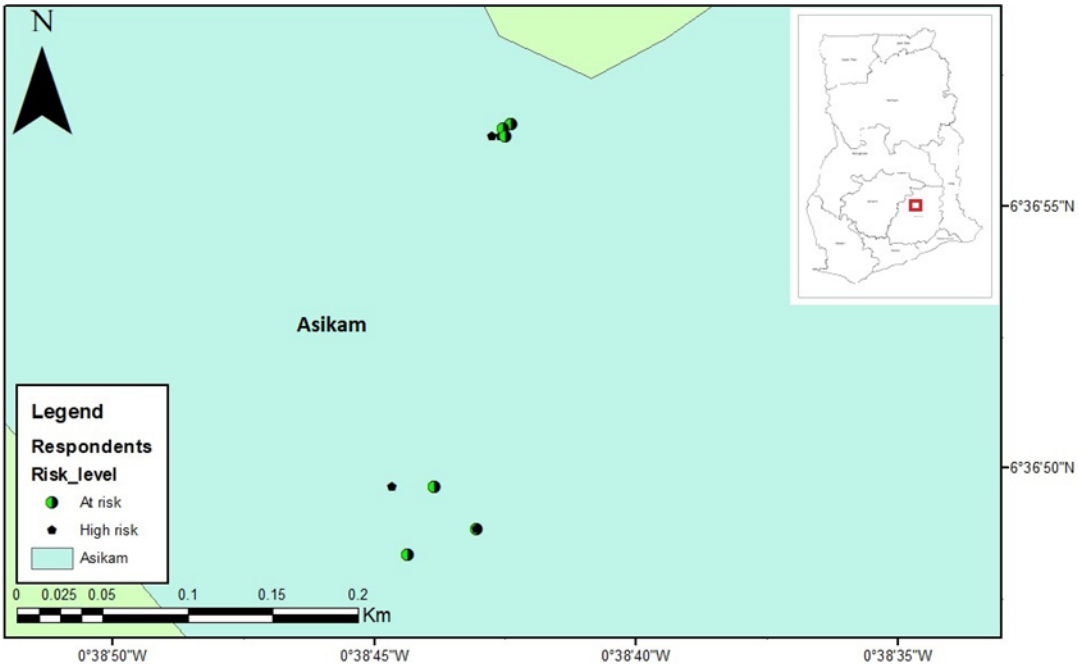

Figure: 17. Map of Asikam showing bat zoonotic outbreak locations. Asikam was ranked the third most vulnerable locality to bat zoonoses outbreak.

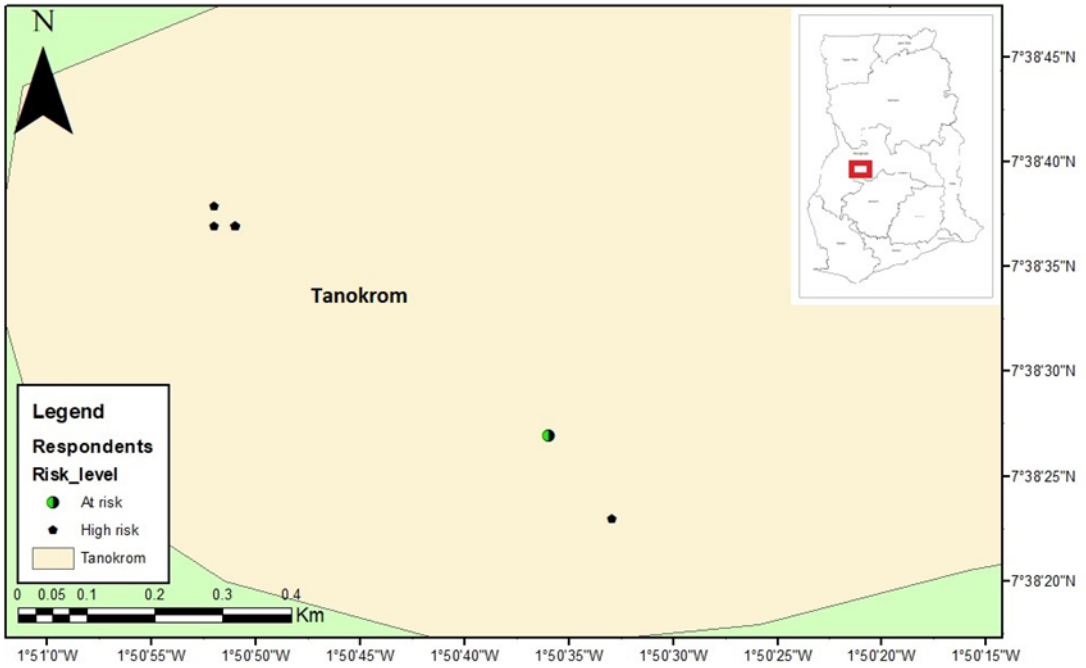

Figure: 18. Map of Tanokrom showing bat zoonotic outbreak locations. Tanokrom was ranked among the most vulnerable localities to bat zoonoses outbreak.

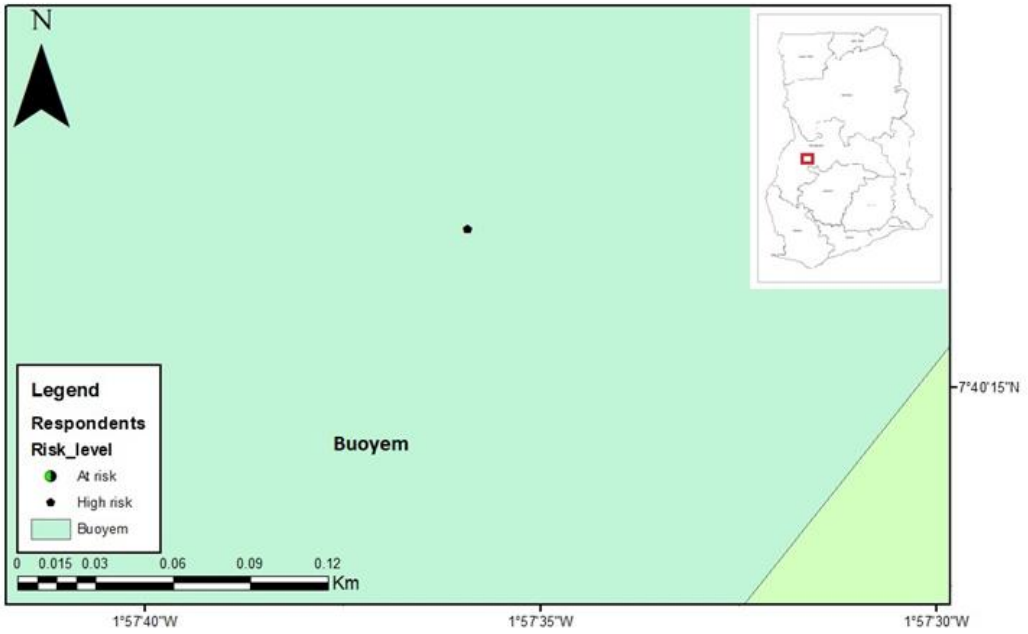

Figure: 19. Map of Buoyem showing bat zoonotic outbreak locations.

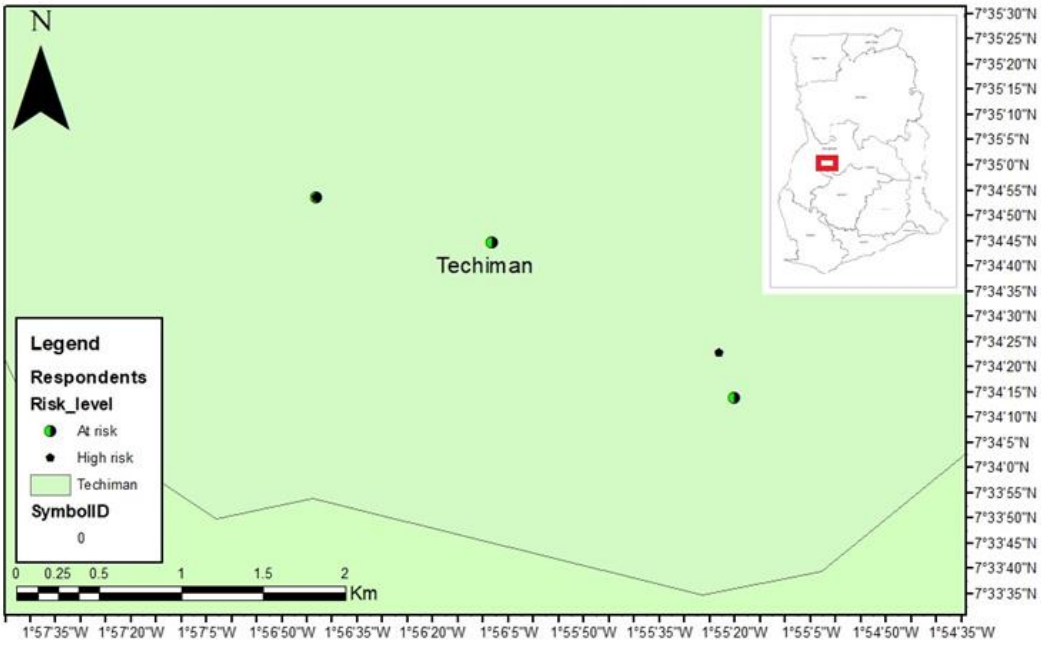

Figure: 20. Map of Techiman showing bat zoonotic outbreak locations.

Appendix 3: Geographic database and risk levels of bat-bushmeat actors surveyed in six localities in southern Ghana

Table 5: Geographic database and risk levels of hunters interviewed in all study localities

Locality	Risk level	N (Latitude)	W (Longitude)
Asikam	High risk	6.61566	0.64519
Asikam	High risk	06° 36' 48.9"	000° 38' 43.2"
Asikam	High risk	06° 36' 48.4"	000° 38' 44.5"
Asikam	At risk	06° 36' 56.6"	000° 38' 42.5"
Asikam	High risk	06° 36' 49.7"	000° 38' 44.0"
Asikam	High risk	06° 36' 48.4"	000° 38' 44.5"
Asikam	High risk	06° 36' 48,4"	000° 36' 44.5"
Asikam	High risk	06° 36' 48.9"	000° 38' 43.2"
Asikam	High risk	06° 36' 48.4"	000° 38' 44.5"
Asikam	High risk	6.61566	0.64524
Asikam	High risk	6.61566	0.64519
Bouyem	At risk	07° 40' 17"	001° 57'36"
Bouyem	High risk	07° 40' 17"	001° 57' 36"
Ntomem	High risk	06° 32' 37.8"	000° 36' 12.12"
Ntomem	High risk	06° 32' 26.1"	000° 36' 15.1"
Ntomem	High risk	06° 32' 47.1"	000° 36' 08.2"
Ntomem	High risk	06° 32' 47.1"	000° 36' 08.2"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 32' 27.1"	000° 36' 18.1"
Ntomem	High risk	06° 32' 27.1"	000° 36' 18.1"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	At risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 32' 26.1"	000° 36' 15.1"
Ntomem	High risk	06° 32' 47.1"	000° 36' 08.2"
Ntomem	High risk	06° 32' 18.9"	000° 36' 18.3"
Ntomem	High risk	06° 32' 19.4"	000° 36' 21.4"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 32' 37.8"	000° 36' 12.2"
Ntomem	High risk	06° 32' 19.4"	000° 36' 21.4"
Ntomem	High risk	06° 32' 20.6"	000° 36' 20.8"
Tanoboase	High risk	07° 39' 49"	001° 52' 09"
Tanoboase	High risk	07° 39' 46"	001° 52' 13"
Tanoboase	At risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"

Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 43"	001° 52' 05"
Tanoboase	High risk	07° 39' 51"	001° 52' 06"
Tanoboase	High risk	07° 39' 44.340"	001° 52' 05.544"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 43.040"	001° 52' 05.610"
Tanoboase	High risk	07° 39' 42"	001° 52' 14"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 49"	001° 52' 09"
Tanoboase	High risk	07° 39' 51"	001° 52' 06"
Tanoboase	High risk	07° 39' 46"	001° 52' 13"
Tanoboase	High risk	07° 39' 44"	001° 52' 03"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 51"	001° 52' 08"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanokrom	High risk	07° 38' 37"	001° 50' 5"
Tanokrom	High risk	07° 38' 37"	001° 50' 51"
Tanokrom	High risk	07° 38' 37"	001° 50' 52"
Tanokrom	High risk	07° 38' 27"	001° 50' 36"
Tanokrom	High risk	07° 38' 37"	001° 50' 51"
Tanokrom	High risk	07° 38' 37"	001° 50' 51"
Tanokrom	At risk	07° 38' 37"	001° 50' 51"
Techiman	At risk	07° 34' 45"	001° 56' 08"
Techiman	High risk	07° 34' 45"	001° 56' 08"
Techiman	At risk	07° 34' 54"	001° 56' 43"

Table 5: Geographic database and risk levels of vendors interviewed in all study localities

Locality	**Risk level**	**N (Latitude)**	**(W (Longitude)**
Ayimana(Techiman)	High risk	07° 34' 23"	001° 55' 23"
Dwomo (Techiman)	At risk	07° 34' 45"	001° 56' 08"
Tanoboase	High risk	07° 39' 42"	001° 52' 11"
Tanoboase	High risk	07° 39' 42"	001° 52' 14"
Asikam	High risk	6.61566	0.64519
Kyinsuase (main market, Techiman)	At risk	07° 34' 54"	001° 56' 43"
Locality	Risk level	N (Latitude)	(W (Longitude)
Tanoboase	At risk	07° 39' 51.736"	001° 52' 06.401"
Tanoboase	High risk	07° 39' 44"	001° 52' 08"
Tanoboase	High risk	07° 39' 51"	001° 52' 00"
Tanoboase	High risk	07° 39' 48"	001° 52' 13"
Tanoboase	High risk	07° 39' 46.38"	001° 52' 13"
Tanoboase	High risk	07° 39' 42"	001° 52' 12"
Tanoboase	At risk	07° 39' 44"	001° 52' 11"
Tanoboase	At risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 42"	001° 52' 14"
Tanoboase	High risk	07° 39' 51"	001° 52' 06"
Tanoboase	High risk	07° 39' 43"	001° 52' 08"
Tanoboase	High risk	07° 39' 43"	001° 52' 05"
Tanoboase	At risk	07° 39' 42"	001° 52' 11"
Tanoboase	High risk	07° 39' 44"	001° 52' 11"
Tanoboase	High risk	07° 39' 46"	001° 52' 13"
Tanoboase	High risk	07° 39' 49"	001° 52' 12"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 50"	001° 52' 06"
Tanoboase	High risk	07° 39' 44"	001° 52' 06"
Tanoboase	High risk	07° 39' 44"	001° 52' 05"
Tanoboase	High risk	07° 39' 49"	001° 52' 11"
Tanoboase	High risk	07° 39' 49"	001° 52' 09"
Tanokrom	High risk	07° 38' 38"	001° 50' 52"
Tanokrom	High risk	07° 38' 23"	001° 50' 33"
Tanokrom	High risk	07° 38' 37"	001° 50' 51"
Techiman	At risk	07° 38' 27"	001° 50' 36"
Techiman	At risk	07° 34' 14"	001° 55' 20"
Asikam	At risk	06° 36' 49.7"	000° 38' 44.0"
Asikam	At risk	06° 36' 49.7"	000° 38' 44.0"
Asikam	At risk	06° 36' 48.4"	000° 38' 44.5"
Asikam	At risk	06° 36' 48.4"	000° 38' 44.5"
Asikam	At risk	06° 36' 48.9"	000° 38' 43.2"

Asikam	At risk	06° 36' 56.6"	000° 38' 42.5"
Asikam	High risk	06° 36' 56.6"	000° 38' 42.5"
Asikam	High risk	06° 36' 49.7"	000° 38' 44.8"
Asikam	High risk	06° 36' 48.9"	000° 38' 43.2"
Asikam	High risk	06° 36' 48.4"	000° 36' 44.5"
Asikam	At risk	06° 36' 48.4"	000° 36' 44.5"
Asikam	High risk	06° 36' 56.6"	000° 38' 42.5"
Asikam	At risk	06° 36' 56.6"	000° 38' 42.5"
Asikam	At risk	6.6157	0.64518
Asikam	At risk	6.61566	0.64517
Ntomem	High risk	06° 32' 25.0"	000° 36' 12.9"
Ntomem	At risk	06° 32' 47.1"	000° 36' 08.2"
Ntomem	At risk	06° 32' 47.1"	000° 36' 08.2"
Ntomem	At risk	06° 33' 37"	000° 44' 26"
Ntomem	At risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 32' 19.4"	000° 36' 21.4"
Ntomem	High risk	06° 32' 18.9"	000° 36' 18.3"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 33' 37"	000° 44' 26"
Ntomem	High risk	06° 32' 25.0"	000° 36' 12.9"
Ntomem	At risk	06° 32' 25.0"	000° 36' 12.9"
Ntomem	High risk	06° 32' 26.1"	000° 36' 15.1"
Ntomem	High risk	06° 32' 20.6"	000° 36' 20.8"
Ntomem	High risk	06° 32' 20.6"	000° 36' 20.8"

Appendix 4. Some important reasons for engaging in bat-bushmeat activities (statements were translated as recorded in the native Twi language).

- "It's not only because of meat that we hunt, it's because of poverty. Who in his right state of mind will go out at night to search for bats, when all bad and wild animals walk at night? The government is to blame. They are not helping us because they are there only for their stomach. And so, we will also kill the bats to eat and to get money. The great Tano gave us the bats, so we will kill, eat and sell. So long as the great Tano is here, they will be there. If I kill and sell, and I get some Gh₵50 (£7.32), I'm okay for some time. Like I said, it is because of poverty. If we had better things to do, the bats will be begging us to kill but we won't mind them. The bats are also not good. They spoil our cashew. So if we eat them, then it's in the right direction."

Narrated by Show Show at Tanoboase
Note: great Tano: Tano is a river in the vicinity, which is regarded as a god. So great Tano is the great god of river Tano.

- "If you see the bats on a tree, you might think they are leaves. I normally gather them on my farm. Sometimes when the hunters shoot them, they don't die on the spot and fall back as they attempt to fly. If you're lucky, you can get some of the dead bats on your farm. Their soup is really nice. Because the whole meat is used for food, it is very nice".

Narrated by Nanayere at Asikam.

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